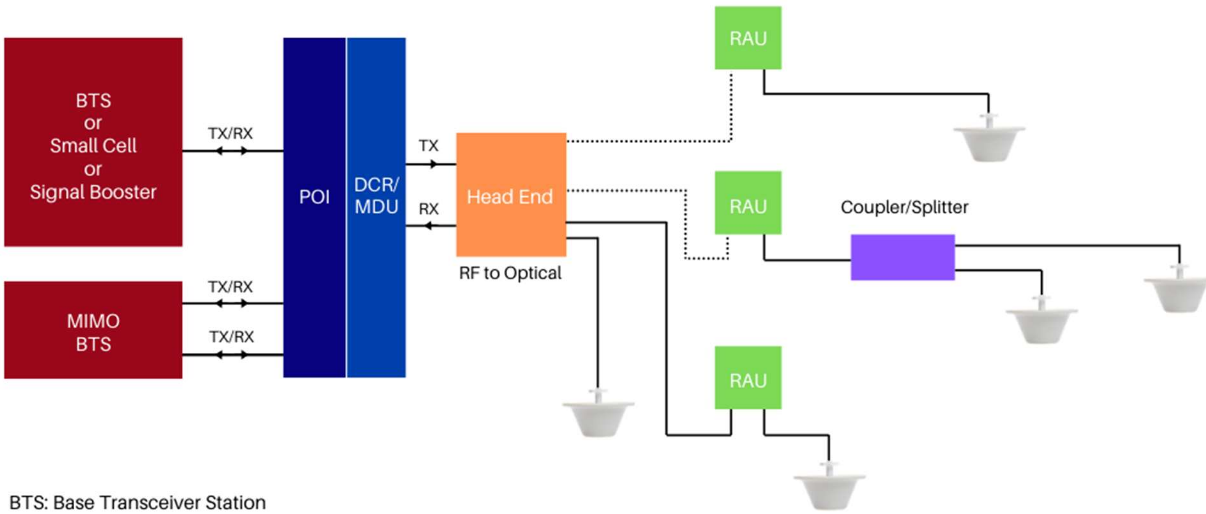
IBS Pocket Guide (Volume 2)

RF Testing of Distributed Antenna Systems (DAS)



BTS: Base Transceiver Station

POI: Point of Interface

DCR: DAS Control Rack

MDU: Matrix Distribution Unit

RAU: Remote Antenna Unit

······· Optical Fiber

—— Coax

Generic DAS Architecture

Contents

Introduction

DAS networks require multi-phase testing for successful deployment; starting from the design phase - which significantly determines the cost of the network infrastructure-through reaching out the on-air acceptance phase.

Commissioning prominently is the most critical phase in DAS roll out as for a system to be optimized, it must be validated for ultimate RF transport and performance via the commissioning process.

A DAS to be properly commissioned, its infrastructure must be functional and trouble free. All infrastructure issues should be demarcated and resolved at this phase.

In this pocket guide we illustrate the most commonly adopted test procedures in DAS deployment to ensure ultimate performance and eliminate any defect before it diffuses in the next phases.

First, we start with CW measurements which comprises multiple test scenarios starting from the design phase (explained in IBS Pocket guide Part 1), infrastructure testing until performing the coverage mapping after installation.

Then comes another vital step which is sweep testing to reveal any RF defect along the path from the BTS to the antenna.

And finally, we illustrate RF level testing using a spectrum analyzer or a receiver to adjust gain and attenuation level of the system in order to maximize sensitivity.

CW Testing

CW stands for Continuous Wave. Which simply means an RF carrier which is transmitted from point A to Point B.

A Transmitter: To transmit an RF signal with a known output power installed in the proposed antenna/BTS location (simulating the presence of a base station or signal source in that location)

A Receiver: To measure the signal on the other end of the DAS or in different locations around the building or even in the city (in case of outdoor model tuning) and compare the received level with the transmitted one for further analysis

Software: To control the measurement process, correlate the measurements with their location and perform any other needed post processing

The main aim of the process is to measure the overall system performance (Path loss or coverage) whether for design, planning or commissioning purposes

Figure 1. Different kinds of Consultix CW transitters for low and high power DAS testing

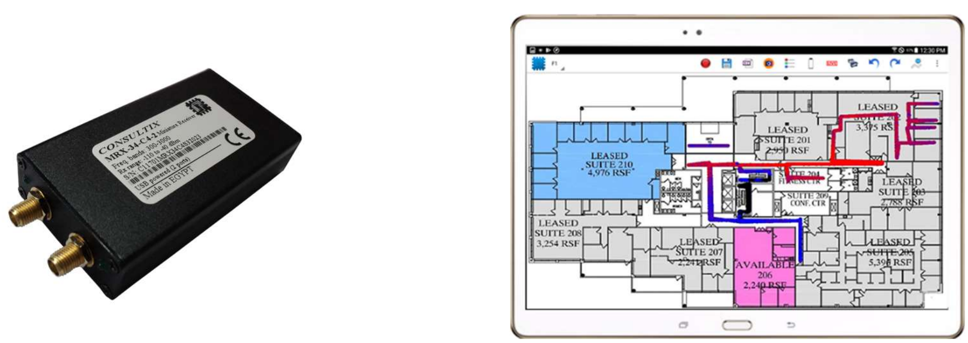


Figure 2. Consultix CW receiver with Android SW

CW Test types for DAS

1- DAS Continuity/Loss

After the DAS is installed, it's often required to ensure that all the DAS segments are properly connected and that signal can flow through them with the expected losses (in another word, Continuity test). Such Continuity / Loss problems may arise due to:

● Human error during installation (such as loose connectors, badly terminated cables...etc)

● Also, wrong or faulty parts

● Wrong directional coupler connections

● And finally, deviation from design guidelines.

Failure to verify continuity and identify loss during commissioning will mean that once the system goes live it will exhibit weird coverage performance which will be much harder to identify and troubleshoot after the radio equipment is connected / site goes live.

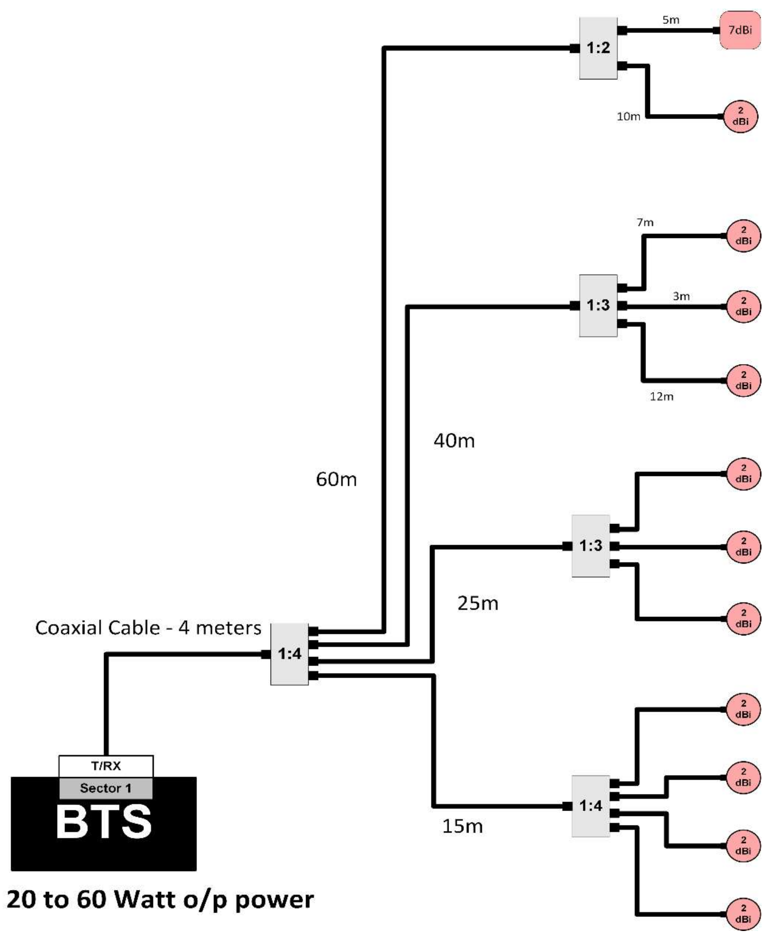


Figure 3. Simplified passive DAS example

2- Downlink & Uplink Levelling

BTS equipment are traditionally very high power for the needs of the DAS, which meant that initially they needed to be attenuated in order to brought down to DAS appropriate levels. Moreover, whenever there are multiple signal sources then the output powers from them have to be attenuated in order to bring them all down to the same level (or according to the design, in order to ensure proper power leveling between multiple operators, multiple technologies...etc.). This is the job of the “Attenuation Tray” which is found in the DAS Head End room.

CW Testing is required to ensure that the attenuation tray is properly setup with the correct attenuation values (for each frequency!).

The typical setup is with the transmitter connected instead of the BTS/Radio Equipment while measurements made on the other side after the RRU using a receiver or spectrum analyzer to verify and adjust the attenuation values.

And same test is repeated in the reverse direction for UL measurements.

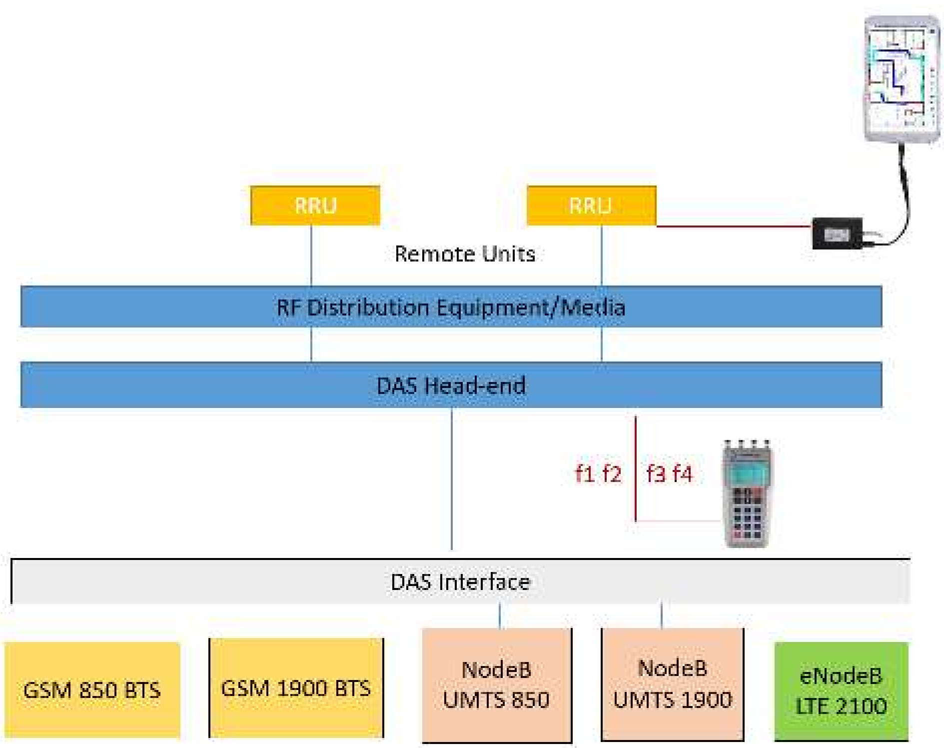


Figure 4. Injecting CW signal for downlink adjustment

3- Coverage Mapping

Also known as Post-Build CW testing which is conducted after everything is installed and functioning properly. The purpose of this test is to ensure that the DAS infrastructure achieves the design coverage requirements.

Inject a CW signal into the headend RF interface as explained in the figure below, and this should be with the actual power that will be eventually operational at this point.

And using a walk-test receiver, verify that the actual coverage across the whole floor is met.

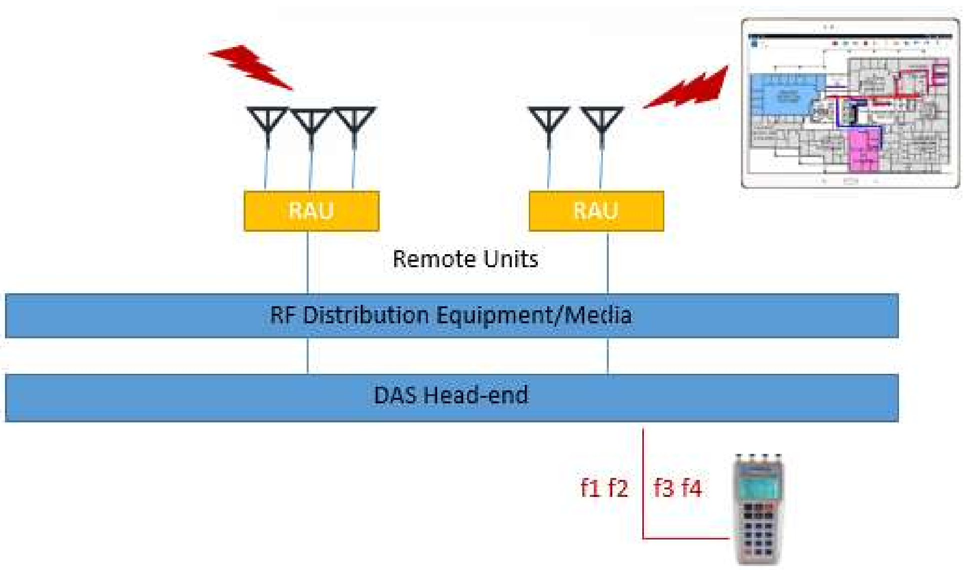
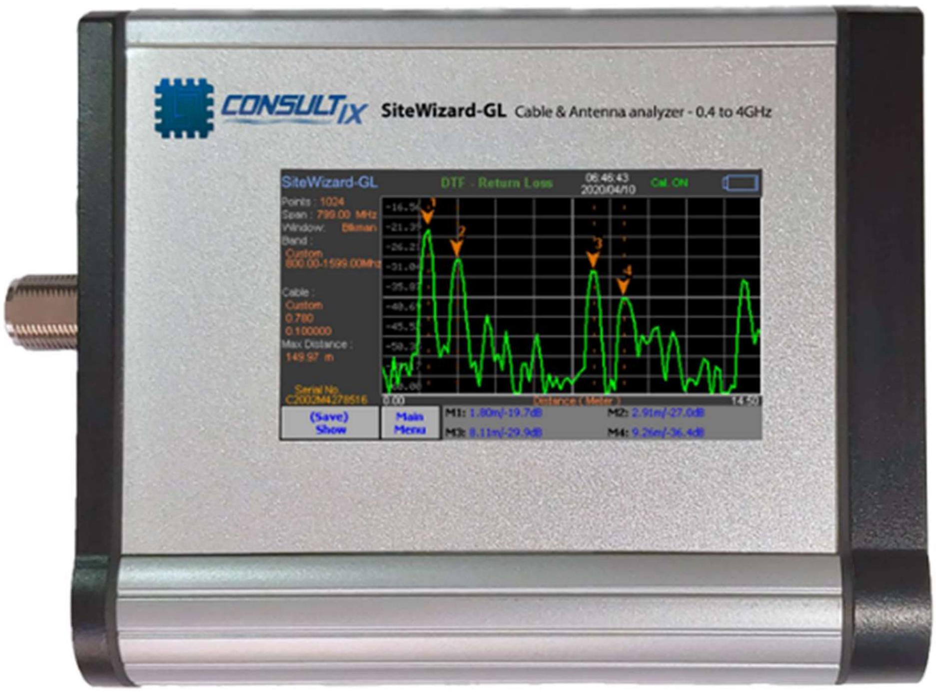


Figure 5. Injecting CW signal for coverage mapping

DAS Sweep Testing



Here a sweep tester (AKA cable/antenna analyzer) is used to detect any mismatch along the RF path.

Mismatches occur when there's a problem with a coaxial component (cables, connectors or even an antenna…) that causes a change of impedance along the signal path, this makes a part of the signal getting reflected back to the source and the total transmitted power falls below what’s required by the design. This results in loss of coverage, dropped calls, degraded MIMO performance and suboptimal performance allover.

Connectors will be the main source of mismatches (since a lot can get wrong with them very easily) so they should be your first suspect, followed by the cables themselves… Antenna faults do happen but they are far in-between.

The importance of Sweep testing is that such problems are practically unavoidable. Even with good, brand-new coaxial components, a lot can go wrong during installation, lose or poorly installed connectors, cables bent beyond their most allowed radius even nails that go through the cable itself and the situation of course gets worse with older installations.

Sweep testing is a special topic, so reader can refer to our article “30 sweep testing tips” for the best practices in this regard. However here we will address its adoption in DAS projects

1- Segment Sweep Test

The first test explained here is the Segment Sweep Test. The objective of this test is to verify the path from the RAN equipment to Headend as below.

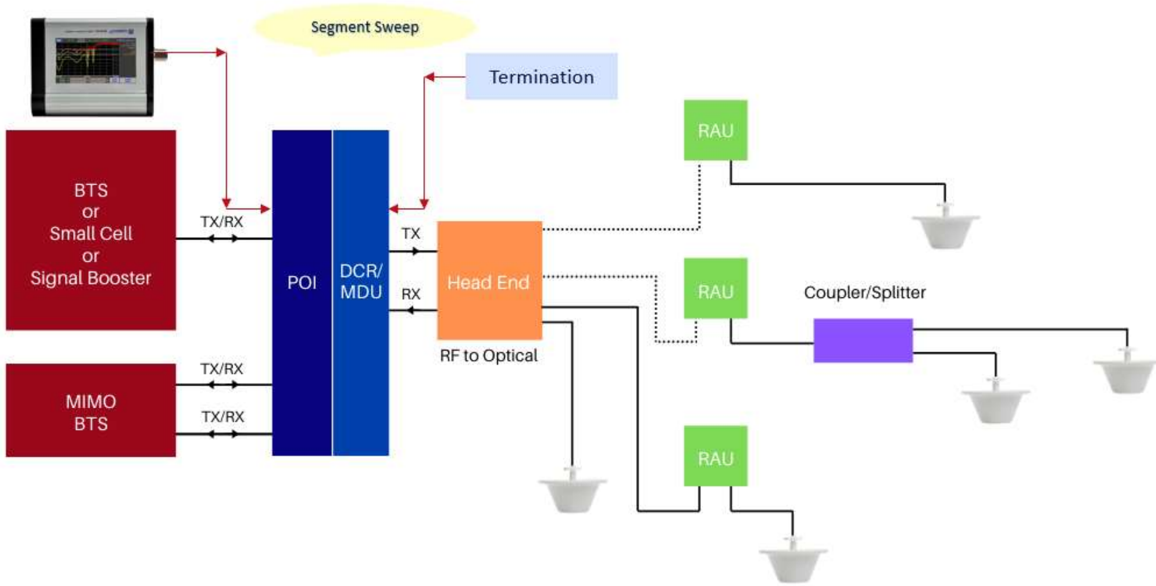


Figure 6. Connection of tester during segment sweep

2- System Sweep Test

Once all the segment sweeps are complete, its required to conduct Distance-To-Fault Return Loss (DTF-RL) system sweeps. This is performed from each DAS remote unit out to the associated antennas. This includes the whole feeders, jumpers and passive components.

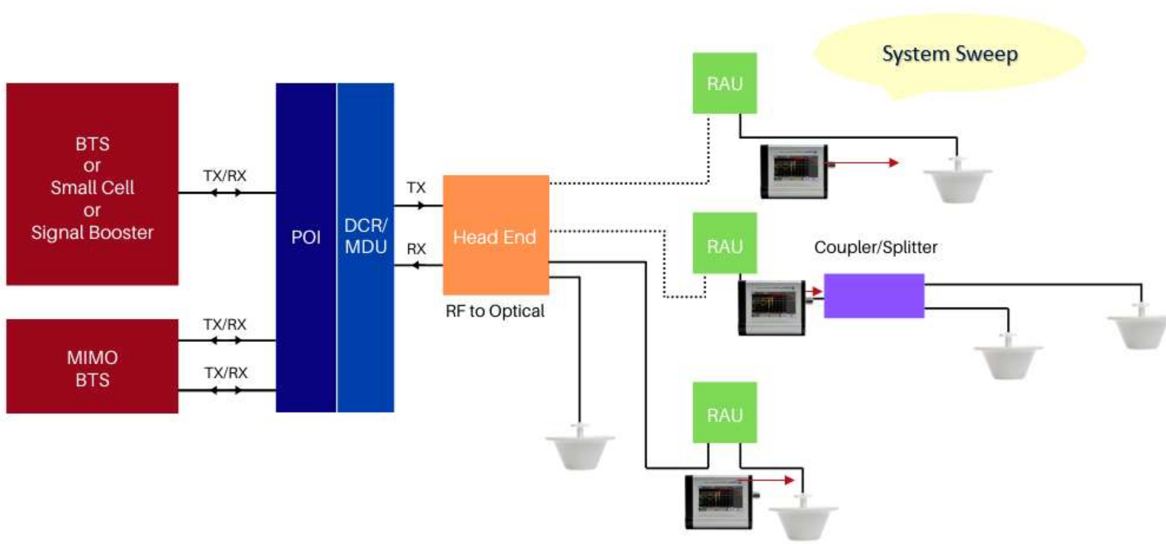


Figure 7. Connection of tester during System sweep

3- DTF (Distance to Fault) Interpretation

To get more familiar with DTF measurements and translate its data easily, let's take a real example here, consider this setup of 2 splitters, 2 antennas and one open end.

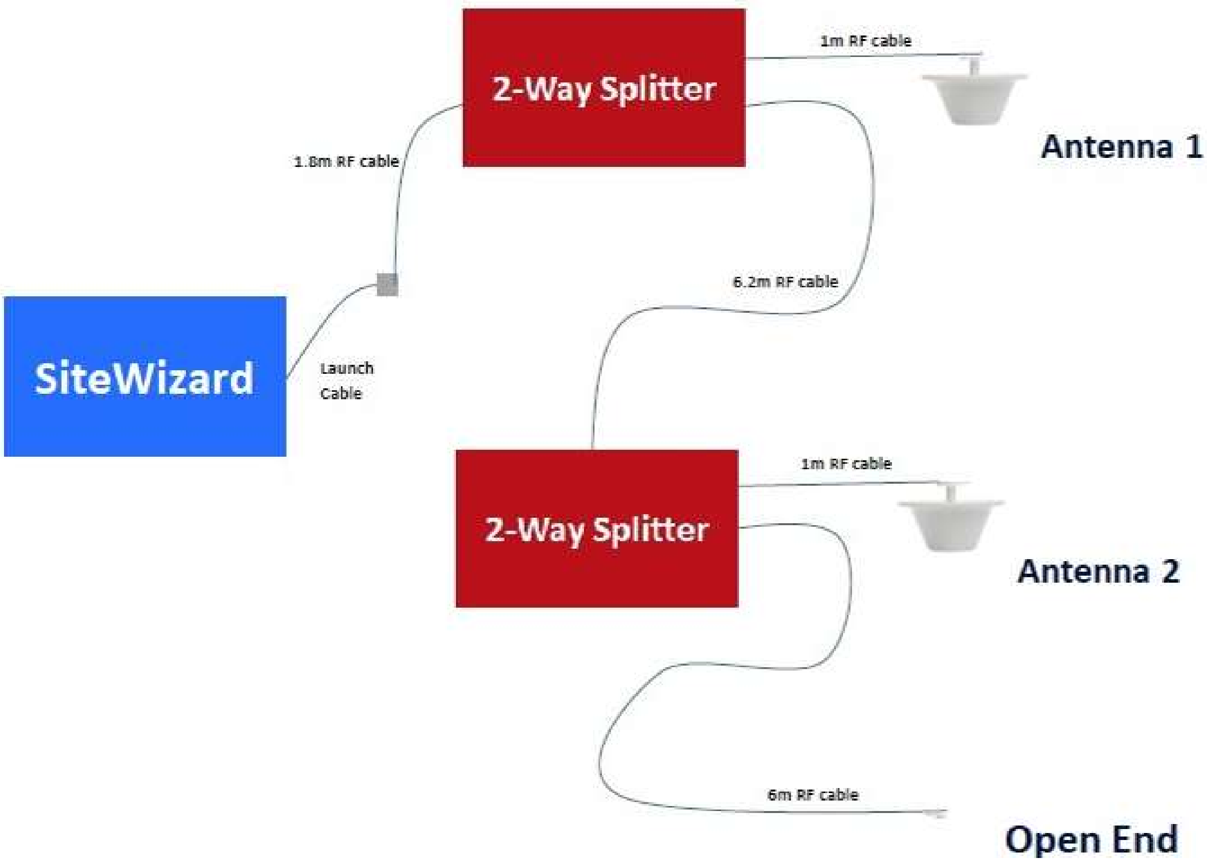


Figure 8. Simplified example of a DAS

- Marker 1 below which is at 1.9 meters, is expressing the first splitter here.
- Marker 2 at around 3 meters is expressing the first antenna attached to that splitter
- Marker 3 at 8.8 meters is expressing the first splitter here.
- Marker 4 meter at 15 meters is expressing the final point of the setup which is the open end.

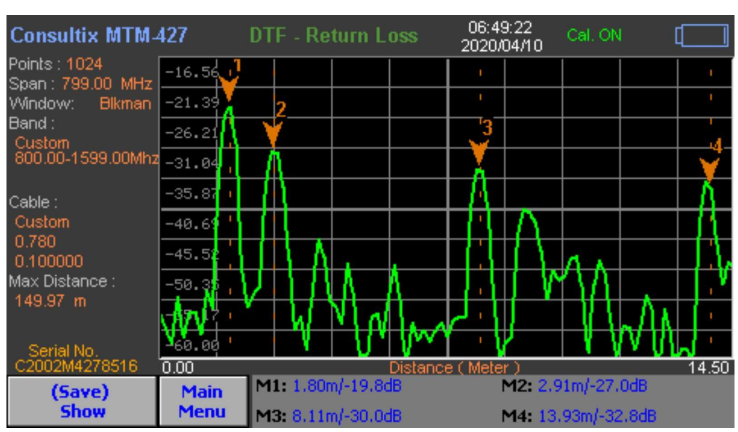


Figure 9. DTF Testing of the system example above

4- DTF Optimization

In the same example lets see what happens when user chose the wrong cable settings in the sweep tester.

In the first curve, the wrong cable is selected, while in the second curve the right cable is selected.

We see the results of all markers in the summary table below.

Try to recognize how similar the measurements with right cable settings are similar to the actual distances

Figure 10.a. DTF with wrong cable settings

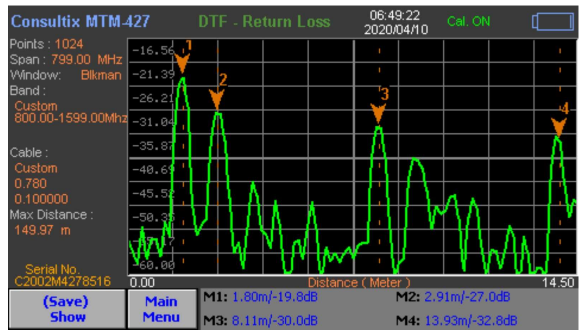


Figure 10.b. DTF with right cable settings

Marker	Actual Distance	With wrong Cable settings	With right cable settings
M1	1.8 meters	1.94 meters	1.8 meters
M2	2.85 meters	3.08 meters	2.91 meters
M3	8.05 meters	8.78 meters	8.11 meters
M4	14.05 meters	15.11 meters	13.93 meters

Table 1. Marker readings of the two DTF curves above

Maximize Sensitivity

Uplink noise can be a serious limiting factor to active DAS systems, degraded Uplink sensitivity can seriously degrade performance and customer experience as the uplink sensitivity decreases.

1-Baseline Noise Floor Testing

With DAS fully connected and powered on, a base line uplink noise floor measurement should be conducted for each path between the RAN and DAS Remote(s) for each sector.

This measurement will be utilized as the baseline reference for future adjustments related calibration of DAS OEM system parameters and settings necessary to maximize uplink sensitivity.

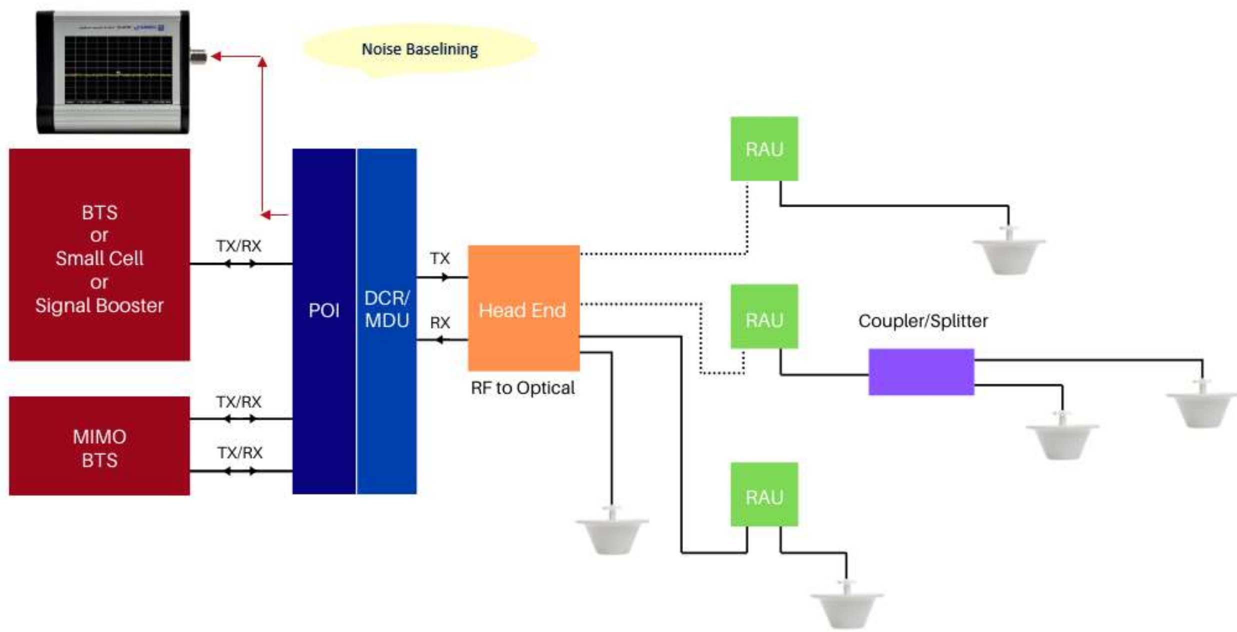


Figure 11. Receiver is connected to measure Noise Floor

Band	Technology	Sector ID	# of RAU's	Measured Noise Floor
850	LTE	1	4	-106.5 dBm
1900	UMTS	2	8	-105.2 dBm
2100	LTE	3	12	-103.6 dBm

Table 2. Measured Noise Floor at each path

2-Final gain/attenuation Settings

The purpose of this step is to make the necessary final gain/attenuation settings adjustments to the DAS OEM equipment to ensure minimum noise contribution of the DAS while achieving optimal signal levels at the BTS referenced to Baseline Noise Floor measurements.

This objective shall be accomplished by incrementally turning on each remote unit (measuring and adjusting system parameters, firmware or hardware to minimize noise contribution upon addition of each remote). This step shall be repeated until all remote units have been added for that sector.

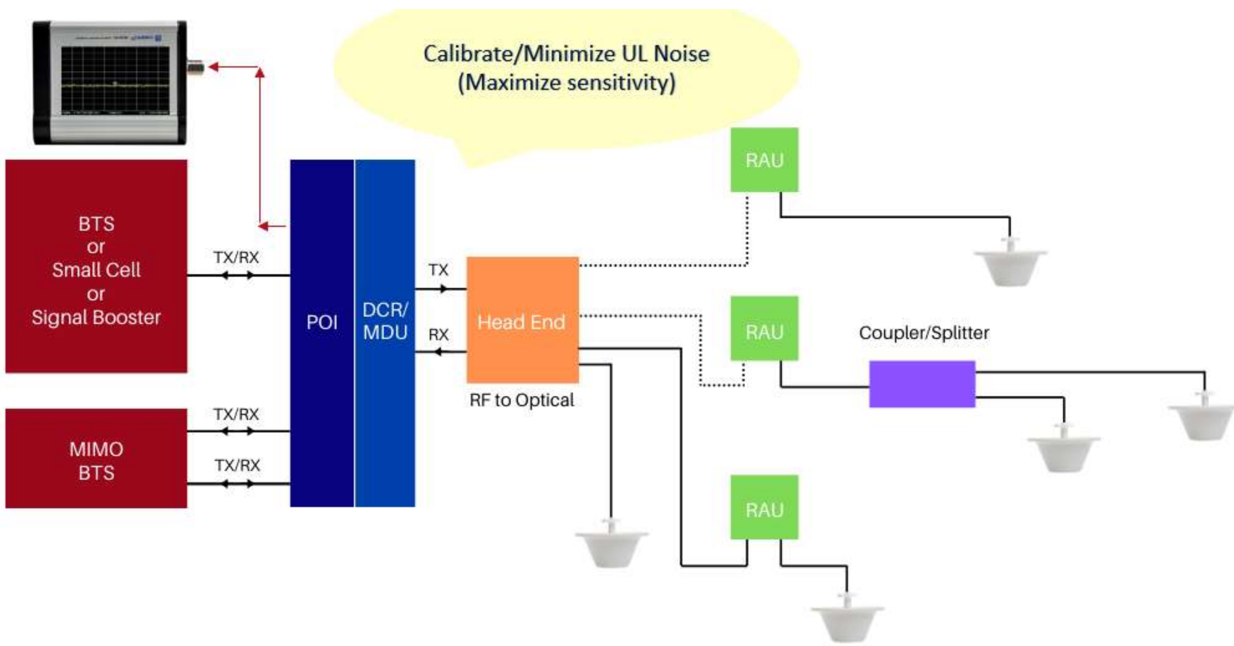


Figure 12. Receiver is connected during sensitivity adjustments

Band	Technology	Sector ID	# of RAU's	Noise (w/o RAU's)	Noise (with RAU's)
850	LTE	1	4	-106.5 dBm	-105.7 dBm
1900	UMTS	2	8	-105.2 dBm	-103.2 dBm
2100	LTE	3	12	-103.6 dBm	-101.5 dbm

Table 3. Noise level before and after remote antenna units are added

www.consultixwireless.com